

1 **WHAT IS CLAIMED IS:**

2 1. A compact fuel processor for converting a hydrocarbon fuel feed into
3 hydrogen rich gas, comprising a processor assembly containing multiple concentric
4 vessels for converting the hydrocarbon fuel feed into the hydrogen rich gas, wherein the
5 hydrogen rich gas is suitable for direct feed to a fuel cell.

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7 2. The compact fuel processor of claim 1, wherein the processor assembly
8 comprises:

9 an oxidation core vessel containing an oxidation catalyst;
10 a reforming vessel surrounding the oxidation core vessel and forming a first
11 annular space filled with autothermal reforming catalyst;

12 a desulfurizing vessel surrounding the reforming vessel and forming a second
13 annular space filled with desulfurization catalyst;

14 a shift vessel surrounding the desulfurizing vessel and forming a third annular
15 space filled with water gas shift catalyst; and

16 a preferred oxidation vessel surrounding the shift vessel and forming a fourth
17 annular space filled with preferred oxidation catalyst.

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19 3. The compact fuel processor of claim 2, wherein the oxidation core vessel
20 oxidizes fuel cell anode tail gas to produce a hot exhaust gas.

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22 4. The compact fuel processor of claim 3, wherein the hot exhaust gas
23 preheats the hydrocarbon fuel.

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25 5. The compact fuel processor of claim 2, further comprising an electric
26 heater for preheating the anode tail gas prior to introducing the anode tail gas to the
27 oxidation core vessel.

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29 6. The compact fuel processor of claim 2, further comprising a second
30 desulfurizing vessel external to the processor assembly for desulfurizing the hydrocarbon
31 fuel feed.

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2 7. The compact fuel processor of claim 6, wherein the second desulfurizing
3 vessel is a replaceable canister.

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5 8. The compact fuel processor of claim 4, wherein the hydrocarbon fuel feed
6 is sequentially introduced to the first annular space, then to the second annular space,
7 then to the third annular space, and then to the fourth annular space to produce the
8 hydrogen rich gas.

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10 9. The compact fuel processor of claim 8, further comprising a plurality of
11 cooling coils for removing the heat of reaction produced in the first annular space, the
12 second annular space, the third annular space, and the fourth annular space.

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14 10. The compact fuel processor of claim 9, wherein a circulating coolant flows
15 through the cooling coils.

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17 11. The compact fuel processor of claim 10, wherein the circulating coolant is
18 selected from a group consisting of air, water, and the hydrocarbon fuel feed.

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20 12. The compact fuel processor of claim 2, wherein the each annular space is
21 surrounded by heat resisting refractory.

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23 13. A compact fuel processor for converting a hydrocarbon fuel feed into
24 hydrogen rich gas, comprising:

25 a reforming module for converting the hydrocarbon fuel feed into the hydrogen
26 rich gas, wherein the hydrogen rich gas is suitable for direct feed to a fuel cell; and

27 an oxidizing module for oxidizing fuel cell anode tail gas to produce a hot exhaust
28 gas, wherein the hot exhaust preheats the hydrocarbon fuel feed to the reforming module.

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30 14. The compact fuel processor of claim 13, wherein the oxidizing module
31 comprises:

1 a first heat exchanger core;
2 an oxidation core vessel containing an oxidation catalyst; and
3 a first desulfurizing vessel surrounding the oxidation core vessel and forming a
4 first annular space filled with desulfurization catalyst; and
5 wherein the oxidation core vessel oxidizes the fuel cell anode tail gas to produce a
6 hot exhaust gas; and
7 wherein the hydrocarbon fuel feed is preheated by the hot exhaust gas in the first
8 heat exchanger coil to produce a preheated hydrocarbon fuel feed; and
9 wherein the preheated hydrocarbon fuel feed is desulfurized in the first annular
10 space to create a desulfurized hydrocarbon fuel feed.

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12 15. The compact fuel processor of claim 14, wherein the oxidation core vessel
13 has a first set of external vertical fins for further preheating the preheated hydrocarbon
14 fuel feed to produce a second preheated hydrocarbon fuel feed, and wherein the second
15 preheated hydrocarbon fuel feed becomes the hydrocarbon fuel feed introduced to the
16 first annular space.

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18 16. The compact fuel processor of claim 13, wherein the reforming module
19 comprises:

20 a second heat exchanger coil;
21 a reforming core vessel containing an autothermal reforming catalyst bed;
22 a second desulfurizing vessel surrounding the reforming core vessel and forming
23 a second annular space filled with desulfurization catalyst;
24 a shift vessel surrounding the second desulfurizing vessel and forming a third
25 annular space filled with water gas shift catalyst; and
26 a preferred oxidation vessel surrounding the shift vessel and forming a fourth
27 annular space filled with preferred oxidation catalyst; and
28 wherein the hydrocarbon fuel feed is preheated by the hydrogen rich gas in the
29 second heat exchanger coil to produce a third preheated hydrocarbon fuel feed; and

1 wherein the third preheated hydrocarbon fuel feed is sequentially introduced to
2 the reforming core vessel, then to the second annular space, then to the third annular
3 space, and then to the fourth annular space to produce the hydrogen rich gas.

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5 17. The compact fuel processor of claim 16, wherein the hydrocarbon fuel
6 feed is a desulfurized hydrocarbon fuel feed.

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8 18. The compact fuel processor of claim 16, wherein the reforming core vessel
9 has a second set of external vertical fins for further preheating the third preheated
10 hydrocarbon fuel feed to produce a fourth preheated hydrocarbon fuel feed, and wherein
11 the fourth preheated hydrocarbon fuel feed becomes the hydrocarbon fuel feed introduced
12 to the reforming core vessel.

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14 19. The compact fuel processor of claim 16, wherein the third annular space
15 has a third heat exchanger coil for reaction temperature control.

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17 20. The compact fuel processor of claim 16, further comprising an electrical
18 heater for starting up the autothermal reforming catalyst bed.

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20 21. A compact fuel processor for converting a hydrocarbon fuel feed into
21 hydrogen rich gas, comprising:

22 a heat exchanger coil;

23 a reforming core vessel containing an autothermal reforming catalyst bed;

24 a desulfurizing vessel surrounding the reforming core vessel and forming a first
25 annular space filled with desulfurization catalyst;

26 a shift vessel surrounding the desulfurizing vessel and forming a second annular
27 space filled with water gas shift catalyst; and

28 a preferred oxidation vessel surrounding the shift vessel and forming a third
29 annular space filled with preferred oxidation catalyst; and

30 wherein the hydrocarbon fuel feed is preheated by the hydrogen rich gas in the
31 heat exchanger coil to produce a preheated hydrocarbon fuel feed; and

1 wherein the preheated hydrocarbon fuel feed is sequentially introduced to the
2 reforming core vessel, then to the second annular space, then to the third annular space,
3 and then to the fourth annular space to produce the hydrogen rich gas.

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